Complications of laparoscopic pelvic surgery: recognition, management and prevention

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Laparoscopic surgery has many advantages but it is not without complications. The complexity of the surgery significantly influences the complication rate. Laparoscopic surgeons ought to be aware of the possible complications and how they could be prevented, recognized without delay, and managed safely and efficiently. Important complications include injuries to the vessels, bowel and urinary tract. Incisional hernia ought to be reduced by careful closure of the fascia whenever a trocar ≥10 mm is used at the extroumbilical site. Gas embolism is a rare but potentially life threatening complication. Shoulder pain is a minor complication but is exceedingly common; it is less likely to occur if as much gas as possible is removed at the end of the operation while the patient is still in head down Trendelenburg position. Rare complications include pneumothorax, subcutaneous and pre-peritoneal emphysema, cardiac arrhythmia, nerve injury and venous thrombosis. Laparoscopic surgeons should also understand the principles of electrosurgery and how to avoid complications arising from the use of electrical energy including capacitative coupling, direct coupling and insulation failure.

Key words: complications/injuries/ laparoscopic surgery/safety

Introduction
Laparoscopy has been used by gynaecologists for over 20 years. One of the pioneers of laparoscopy was Patrick Steptoe, who aspirated pre-ovulatory oocytes at laparoscopy for in-vitro fertilization (Steptoe et al., 1980). Initially, its use was confined to diagnosis and simple therapeutic procedures such as laparoscopic sterilization. More recently, laparoscopic surgery has become more sophisticated and includes a large variety of different types of surgery. In this paper, the complications of laparoscopic surgery, including early recognition, management and prevention, are reviewed.

Incidence
The incidence of complications depends on a number of factors. Firstly, it depends on whether the procedure is a diagnostic one, or whether a surgical procedure has been carried out. The complexity of the surgery clearly influences the complication rate. For example, Querleu et al. (1993) reported that the non-lethal complication rate was 1.08 per thousand cases in diagnostic laparoscopy or minor laparoscopic surgery, versus 5.23 per thousand in major or advanced laparoscopic surgery. It is therefore difficult to compare the various published series, because most of them consist of heterogeneous populations with a mixture of diagnostic problems and different levels of operative laparoscopy. Secondly, the definition of complications varies in different series. For example, some
authors consider unintended laparotomy as a complication, whereas others do not. Some authors would consider failure to create pneumoperitoneum as a complication, whereas others may not. Certain authors simply group complications under the headings of ‘major’ or ‘minor’. Thirdly, the population selected for laparoscopy has also changed over the years with the increase in laparoscopic surgery skills amongst gynaecologists. Some patients in whom laparoscopy was considered to be contraindicated, e.g. previous laparotomy, are now offered laparoscopic surgery. Finally, there may also be bias in reporting, such that isolated complications in a relatively small series may not be published. Most of the larger series consist of retrospective analyses, which again may underestimate the true incidence of complications, especially minor ones.

**Vascular injury**

Vascular injury may involve abdominal wall vessels or large retroperitoneal vessels.

**Abdominal wall vessels**

Injuries involving the inferior epigastric vessel are the commonest type of vascular complication. The true incidence is unknown, but it is likely to exceed 3/1000 operative laparoscopies (Zaki et al. 1995).

**Recognition**

Bleeding from the inferior epigastric vessels is often obvious during the course of laparoscopic surgery. Occasionally, it may not be apparent until after the trocar has been removed at the end of the operation, because the increased intra-abdominal pressure and retroperitoneal haematoma formation may tamponade even a large vessel injury. This may remain unnoticed until the pressure is gradually reduced at the conclusion of the procedure. It is good practice to inspect all secondary trocar sites for active bleeding before the laparoscope is finally withdrawn. The inspection should be carried out when the intra-abdominal pressure has been lowered following the release of carbon dioxide from the intra-abdominal cavity.

**Management**

Bleeding from the inferior epigastric vessels may be managed by (i) bipolar coagulation, (ii) tamponade, or (iii) suturing.

**Bipolar coagulation.** This may produce quick and adequate haemostasis, provided the vessel has not retracted into the abdominal wall.

**Tamponade.** This may be achieved by (i) rotating the trocar sleeve through 360° and, if bleeding is successfully arrested, the tamponade should be applied for at least 5 min; (ii) upsizing the port; (iii) using a Foley catheter: a size 14 Foley catheter may be inserted through the cannula, the balloon is then inflated with 15–30 ml of normal saline. The cannula is then removed and the balloon is pulled up to produce pressure on the bleeding vessel. If the bleeding is successfully stopped, the tamponade may be sustained by clamping the Foley catheter close to the abdominal wall. If bleeding continues, or recurs after the tamponade is released (at the end of 5 min, or at the end of the operation), suturing is necessary to stop the bleeding. Some laparoscopic surgeons advocate continuing the tamponade for up to 24 h, and removing the Foley catheter after the patient has returned to the ward (Aharoni et al., 1997). The concern in this situation is that, following the removal of the catheter, one may not be certain whether the bleeding has recurred and if it does, the diagnosis may be delayed and the patient would need to return to the operating theatre for suturing.

**Suturing.** (i) A through and through suture may be applied by using a large curved needle; however, this may be difficult if the patient is obese. (ii) If a straight needle is used, the entry and exit of the needle through the abdominal wall is achieved with the help of a laparoscopic needle holder/grasper, under direct laparoscopic control. (iii) A specially designed ‘J’ shaped peritoneal closure needle has been described by Phipps and Taranissi (1994). The needle (Rocket of London, Watford, UK), has a leading-end fenestration for carrying the closure suture, and the round-bodied, pointed tip can be shielded by an integral guard sheath. (iv) If the bleeding is significant, or if there is doubt that the above measures have achieved satisfactory haemostasis, a small abdominal incision (~3 cm) should be made over the bleeding site, which would then permit the identification of the bleeder, following which the bleeder is clamped and ligated. Similarly, an enlarging haematoma is best managed by minilaparotomy (Bateman et al., 1996).

The following case report by Hurd et al. (1993) is enlightening: ‘The inferior epigastric artery was lacerated by a 12 mm trocar. A large taper needle was introduced into the peritoneal cavity through the incision, a laparoscopic needle holder was then used to direct the needle back out of the peritoneal cavity through the incision, a ligature was tied, resulting in good haemostasis. However, the patient developed shock in the recovery room. Subsequent Pfannenstiel incision revealed a completely severed inferior epigastric artery.’
The authors speculated that the likely reason for the recurrent bleeding was that the injured vessel was not selectively ligated, so that as the patient began to move during and after recovery from anaesthesia the ligature was displaced.

**Prevention**

1. Insert the trocar in the lower quadrant, lateral to the rectus sheath, above a line joining the anterior superior iliac spine.
2. Trans-illumination of the anterior abdominal wall will help to identify the superior epigastric vessel.
3. Careful visual inspection of the peritoneum below an arcuate line (where the vessels enter the rectus sheath) will locate the position of the lower part of the inferior epigastric vessel.
4. For lateral ports, identify obliterated hypogastric vessels intraperitoneally in the anterior abdominal wall and ensure puncture remains lateral to it.
5. Use a small (5 mm) trocar in lateral ports (Saidi et al., 1994).

**Large retroperitoneal vessels**

These include the aorta, vena cava and iliac vessels. In most cases, the injury is sustained during the insertion of the Veress needle or the primary trocar. The incidence of major vascular injury in the Royal College of Obstetricians and Gynaecologists (RCOG) study (Chamberlain and Brown, 1978) was 9/10 000 laparoscopies. Mintz (1977) and Baadsgaard et al. (1989) together analysed 47 major vessel injuries during laparoscopy, and reported that most of the major vascular injuries were inflicted by the Veress needle. Penfield (1985) reported on 19 cases of major vascular injury (Table I). Nezhat et al. (1997) reported on eight cases of major retroperitoneal vascular injury during laparoscopic surgery not related to trocar or Veress needle injury, and emphasized the need for proper understanding and safe use of diathermy.

**Presentation**

1. Haemorrhage detected immediately following insertion of the Veress needle or primary trocar: After the Veress needle has been inserted, prior to connecting the tubing and introducing carbon dioxide into the abdominal cavity, with the tap open, blood may ooze out from the open end of the Veress needle. In this situation either the aorta, vena cava, or, more commonly, the common iliac vessel has been traumatized. In the case of the primary trocar, the removal of the primary trocar from the cannula may similarly be associated with a gush of blood through the cannula; in either case, one must never remove the perforating/traumatizing instrument (Veress needle or cannula).
2. Haemorrhage detected following the insertion of the laparoscope: There may be signs of peritoneal or retroperitoneal bleeding, the latter almost always in the form of a haematoma. It is good practice as soon as the laparoscope has been introduced into the abdominal cavity to survey the abdominal cavity, especially the area just beneath the umbilicus, before attention is focused on the pelvis.
3. Sudden drop in blood pressure.

**Table I. Causes and sites of injury during laparoscopic surgery in 19 cases reported by Penfield (1985)**

<table>
<thead>
<tr>
<th>Cause</th>
<th>n</th>
<th>Site</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary trocar</td>
<td>6</td>
<td>Aorta</td>
<td>8</td>
</tr>
<tr>
<td>Veress needle</td>
<td>6</td>
<td>Iliac artery</td>
<td>7</td>
</tr>
<tr>
<td>Secondary lower abdominal trocar</td>
<td>3</td>
<td>Common iliac vein</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Superior mesenteric vessel</td>
<td>1</td>
</tr>
<tr>
<td>Unspecified</td>
<td>4</td>
<td>Duodenal vessel</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Abdominal wall artery</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>Total</td>
<td>19</td>
</tr>
</tbody>
</table>

**Management**

Firstly, the Veress needle or the trocar/cannula must not be removed, because the tip of the instrument may act as a plug to prevent catastrophic bleeding. Instead the tip of the instrument should be pushed slightly in. In the case of blood oozing out through the cannula, the assistant should be asked to place his/her finger over the open end of the cannula. If the cannula is removed it may produce massive blood loss either intraperitoneally or retroperitoneally. In the latter situation, it may be difficult to identify the exact site of injury. An immediate midline laparotomy should be carried out and pressure applied either digitally or with the help of a large pack over the site of the vascular defect. Sometimes a large haematoma makes the identification of the exact site of injury difficult. In such a case, compression may be applied over the aorta. The assistance of a vascular surgeon should have been sought at this stage. Resuscitative measures should already have been initiated by the anaesthetic staff. One should never attempt to put a haemostatic clamp over a large vessel because it may produce further crushing injury to the vessel wall and complicate the subsequent repair procedure.
Prevention

1. Adhere to safe laparoscopic entry techniques.
2. Prior to insertion of the Veress needle/primary trocar, palpate the abdominal wall carefully for any pelvic mass.
3. The trocar must be sharp, preferably with a safety shield.
4. Ensure that the skin incision is adequate. There should be gentle and controlled entry of the trocar. Remember that the greater the force required to insert the trocar, the higher the risk of injury.
5. The Veress needle and primary trocar should be inserted in the direction of the hollow of the sacrum. The tip should be kept to the midline and should not be allowed to wander off sideways (risk of injury to the iliac vessels).
6. There is no evidence to suggest that disposable trocars are safer than reusable ones provided the latter are not blunt.
7. All secondary trocars must be placed under direct vision.
8. Very occasionally, accidental vascular injury may result during the course of laparoscopic surgery from sharp instruments, e.g. diathermy needle or scissors, so it is important that the tip of any sharp instrument is kept under vision at all times and not be allowed to ‘wander’ within the abdominal cavity. If the instrument is not in active use, it ought to be removed.
9. One should be aware that thin patients may be at greater risk of major vessel injury, as the aorta may lie only 3 cm below the umbilicus (Hurd et al., 1991).

Bowel injury

Bowel injury is one of the most important complications of laparoscopic surgery because it is potentially life threatening, especially if the injury is not recognized at the time of operation. In the RCOG survey (Chamberlain and Brown, 1978), the incidence of bowel injury was 1.8:1000. More recently, Zaki et al. (1995) reported two cases of bowel injury among 1508 patients (incidence 1.3:1000). One case involved laparoscopic sterilization and another was a diagnostic laparoscopy for infertility. The incidence is likely to be higher in advanced laparoscopic surgery cases.

Causation

1. Laceration: this is most commonly sustained during the insertion of the Veress needle or the primary trocar.
2. Thermal injury: the bowel may be injured as a consequence of direct burn, direct coupling or capacitative coupling.

Recognition

1. Perforation by Veress needle or trocar: If the tip of the Veress needle or the trocar has entered the bowel lumen, foul smelling gas or greenish fluid may be detected from the open end of the needle/trocar. If in doubt, use a syringe to aspirate. If the injury is not detected at this stage, the laparoscope may be inserted and the characteristic features of the bowel mucosa will establish the diagnosis.
2. Through and through trocar perforation: this may result if a segment of the bowel is adherent to the anterior abdominal wall at the trocar insertion site. The injury may then escape detection. To verify that this type of injury has not occurred, the laparoscope is withdrawn into the trocar and the trocar sleeve is then retracted slowly until the edges of the peritoneum can be visualized. If a through and through injury has occurred, the bowel lumen, instead of the edges of the peritoneum, will be evident. Such a manoeuvre is more likely to detect bowel injury than moving the laparoscope to another site.
3. During the course of laparoscopic surgery, if bowel injury is suspected, laparotomy should be strongly considered because it is much more difficult to exclude bowel injury via the laparoscope. It is possible to carry out the ‘sterile milk test’, by injecting sterile milk into the lumen to confirm the integrity of the bowel wall.

Management

1. Veress needle perforation: Injury caused by the Veress needle may be managed expectantly (Bateman et al., 1996).
2. Trocar injury: Bowel injury sustained by a trocar should be managed by laparotomy. If the injury is diagnosed whilst the tip of the trocar is still in the bowel lumen, it should be left in situ to facilitate localization of the site of injury at laparotomy. The bowel wall should then be carefully inspected for an additional ‘exit’ injury. If the small bowel is involved, primary closure in two layers is adequate. If the large bowel is involved, the treatment options include primary repair, colostomy or segmental resection. The decision is influenced by the extent of the injury and whether the bowel has been prepared. It is wise to seek the assistance of a general surgeon in case of doubt.
3. Thermal injury: Thermal injury of the bowel necessitates segmental resection with a wide margin around the site of injury because thermal damage may extend for a considerable distance from the site of thermal contact (several centimetres).

4. Laceration sustained during laparoscopic surgery: Small bowel injury is usually sustained during laparoscopic adhesiolysis. The laceration may be oversewn either laparoscopically or via laparotomy, depending on the experience of the surgeon. A large bowel laceration may be repaired laparoscopically if the laceration is small and there is minimal soiling (e.g. involving the rectum, and the bowel has been prepared), otherwise it is advisable to proceed to laparotomy and repair. The management of laparoscopic bowel injury has been reviewed by Reich et al. (1991).

**Delayed presentation**

Bowel injury sustained during laparoscopy is often missed at the time of surgery. Zaki et al. (1995) reported two cases of intestinal perforation (one laparoscopic sterilization, one diagnostic laparoscopy for infertility), both of which were missed at the time of surgery, which presented a few days later.

Unrecognized perforation usually presents within 24–48 h. On the other hand, unrecognized thermal injury often presents later, around 4–10 days. Histologically, these two types of injury are different (Levy et al., 1985): traumatic injury is associated with white cell infiltration, capillary ingrowth and fibrin deposition, whereas thermal injury is associated with coagulation necrosis with absence of leukocytic infiltration. The histological differences between traumatic and thermal bowel injury are important because they may be used in court as evidence of the mode of injury.

The clinical picture may be varied. Initially the symptoms may be non-specific, e.g. vomiting, abdominal pain, distension and malaise. Later on, there may be additional features, such as a localized peritoneal abscess or generalized peritonitis. Fever and leukocytosis are usually present. In some cases, the patient may present with features of septic shock.

It must be emphasised that the prognosis for undiagnosed bowel injury depends very much on prompt diagnosis. Soderstrom (1993) reviewed 66 cases of missed intestinal perforation and concluded that if the diagnosis is made after 72 h there is a significant increase in mortality rate (3/13 patients died in that series).

A high index of suspicion in any patient who presents with persistent abdominal pain, nausea, or feeling generally unwell within 2 weeks of laparoscopic surgery is advisable. It requires thorough investigation and careful observation as an inpatient to exclude bowel injury.

Of paramount importance is the education of patients and general practitioners to report symptoms early (including persistence or increase in abdominal pain, nausea, vomiting, temperature, deterioration in general well being) and to return to hospital promptly to avoid delay in diagnosis and management of the condition.

**Prevention**

1. Avoid laparoscopic surgery when there is a substantial risk of significant adhesions between the bowel and the anterior abdominal wall, for instance if a previous operation (laparotomy or laparoscopy) had identified significant intraperitoneal adhesions involving the bowel and the anterior abdominal wall (even if the adhesions had been divided, because they may well have recurred) or multiple operations had been performed for ruptured abscess, inflammatory bowel disease or dense adhesions.

2. Use safety techniques when performing laparoscopy in patients who are presumed to have anterior abdominal wall adhesions: a number of techniques may be used to reduce the likelihood of significant bowel injury, including (i) the establishment of the pneumoperitoneum through the left ninth intercostal space (Reich et al., 1995); (ii) the use of a minilaparoscope to help to identify an alternative, safe site for introduction of the primary trocar; (iii) use of the open laparoscopy method introduced by Hasson (1990) may reduce the likelihood of bowel injury in patients who are likely to have anterior wall adhesions; and (iv) performance of transumbilical puncture of the abdominal wall under direct vision with a 5 mm optically equipped trocar, as described by Semm (1989).

3. The routine use of a nasogastric tube to empty the stomach reduces the risk of injury to the stomach. Gaseous distension of the stomach may be due to assisted positive pressure ventilation before intubation or aerophagia. However, nasogastric tube insertion may be complicated by oesophageal injuries, which could have severe consequences. For the latter reason, very few centres in Britain employ the routine use of a nasal gastric tube to empty the stomach. It is, however, desirable to identify a patient at risk of undue gaseous distension. Gaseous distension is a particular feature of assisted positive pressure ventilation prior to intubation in a paralysed patient. This problem is exacerbated in those patients where airway management in the
anaesthetized state is a problem and consequently higher inflation pressures are required. For these patients, it must be decided pre-operatively to use an alternative technique not requiring positive pressure ventilation with high inflation pressure prior to intubation. Alternatively, if high inflation pressure were indeed used prior to intubation in these patients, then a nasogastric tube must be passed to decompress the stomach.

4. Bowel preparation facilitates operative manoeuvres by increasing intra-peritoneal free space and reducing inadvertent bowel trauma. Additionally, bowel preparation reduces the severity of complications which may occur after bowel perforation.

5. Extensive adhesiolysis should be classified as advanced laparoscopic surgery and should be performed only by experienced laparoscopic surgeons (Querleu et al., 1993).

6. Avoiding thermal injury: This is discussed in a later section.

Injury to the urinary tract

Bladder

Injury to the bladder may result from a secondary suprapubic trocar or from dissection of the bladder during the course of laparoscopic surgery, e.g. laparoscopic hysterectomy or colposuspension. If bladder injury is suspected, methylene blue dye may be instilled into the bladder to establish if there is any leakage of dye. Perforation of the bladder may also result in the escape of gas into the Foley catheter (drainage bag).

Bladder injury recognized during laparoscopy may be sutured in a single layer, followed by bladder drainage for 7–10 days. Bladder injury not recognized during laparoscopy may present a few days later, the patients having lower abdominal discomfort and blood biochemistry results not dissimilar to those of someone in acute renal failure. The diagnosis may be confirmed with a retrograde cystogram. A small defect may be managed conservatively by continuous drainage with a Foley catheter (Saravelos et al., 1996), whereas a larger defect would require repair. A case of vesico-vaginal fistula was reported to present 2 months after total laparoscopic hysterectomy (Chapron et al., 1996).

Prevention

To prevent injury of the bladder at laparoscopy, it is important that the bladder is catheterized before the patient is tilted head downwards. During a long operation, urine may reaccumulate in the bladder, hence an indwelling Foley catheter is advisable in all cases of laparoscopic surgery other than simple ones such as laparoscopic sterilization. There is a natural tendency for gynaecologists to direct the suprapubic trocar towards the retropubic space of Retzius and this should be avoided. This is particularly important if a large trocar is inserted in those who have had a previous Caesarean section, or in those who have undergone multiple pelvic surgery, distorting the peritoneal anatomy.

Ureter

Recognition

1. Immediate/intra-operative: if there is doubt that the ureter has been transected or damaged during the course of laparoscopic surgery, 5–10 ml of indigo carmine may be injected intravenously to verify if there is any leakage of the dye through the ureter.

2. Delay in presentation: (a) Extravasation of urine may follow laceration of the ureter or, less commonly, thermal injury complicated by tissue necrosis. The presentation of the latter injury may be delayed by several days or weeks. The urine leaking into the peritoneal cavity may be absorbed. The presentation is variable and consists of non-specific symptoms such as nausea, vomiting, malaise, leakage of fluid via the trocar sites, abdominal distension and ileus. Blood tests show a characteristic increase in creatinine levels. X-Ray of the abdomen may reveal a ground-glass appearance indicative of fluid collection. The diagnosis should be confirmed by intravenous urogram. (b) Obstructive uropathy may follow accidental stapling of the ureter, or thermal injury resulting in a stricture leading to hydroureter and hydronephrosis. Superimposed infection may result in pyonephrosis. Ureteral injuries are rarely discovered intra-operatively. In a review of 13 ureteral injuries inflicted during laparoscopy, none was diagnosed intra-operatively (Grainger et al., 1990).

In addition, in this series, 12 of the 13 injuries were thought to be due to electrocautery and five were related to bipolar diathermy. This suggests that use of bipolar electrocautery should not produce a false sense of security when operating near the ureter.

Management

A small laceration not amounting to transection of the ureter may be managed by insertion of a ureteric stent, and a single interrupted suture (Gomel and James, 1991; Neven et al., 1993), otherwise the laparoscopic management of ureteric injury is limited. In most cases, laparotomy repair is required. The assistance of a urological surgeon should be sought. The poor outcome of end-to-end anastomosis after ureteral
electrosurgical injury may be due to damage of the vascular supply of the coagulated tissue beyond the extent of the apparent injury, leading to delayed tissue necrosis.

**Prevention**

1. Generous irrigation of pelvic side wall: diathermy of the pelvic side walls, e.g., following ovariolysis to achieve haemostasis, should be accompanied by generous fluid irrigation to cool down the tissue to minimize thermal injury.

2. Hydroprotection: to diathermize endometriotic deposits adjacent to the ureter, 10–20 ml of normal saline solution or Hartman’s solution may be injected via a long needle (e.g., long spinal needle) just beneath the parietal peritoneum, at a point above the ureter, creating a pseudospace and lifting the peritoneum off the pelvic side wall. The water-filled space so created serves to protect the ureter from thermal injury.

3. When oophorectomy is to be carried out, avoid the use of staples. Some reports suggest a high incidence of ureteric injury with staples, especially when used by those not familiar with the instrument (Woodland, 1992).

4. The use of a transilluminating ureteric stent, e.g., in laparoscopic hysterectomy.

5. Most commonly, the ureter is injured near the uterosacral ligaments, as it cannot be identified reliably in this area. Therefore, special attention is required when performing laparoscopic procedures in this anatomical region, particularly in the presence of endometriosis or adhesions.

6. Avoiding thermal injury: this is covered in a subsequent section.

**Table II.** Observations of six cases of incisional hernia amongst 3560 operative laparoscopies (from Kadar et al., 1993)

<table>
<thead>
<tr>
<th>Trocar size</th>
<th>Trocar site</th>
<th>Umbilical</th>
<th>Extraumbilical</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm</td>
<td>0/8771</td>
<td>0/2560</td>
<td>closed 0/175</td>
</tr>
<tr>
<td></td>
<td>open 1/254</td>
<td>open 2/25</td>
<td>closed 3/136</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total 1/429 (0.2%)</td>
<td>total 5/161 (3.1%)</td>
</tr>
</tbody>
</table>

**Incisional hernia**

Incisional hernia rarely occurs at the umbilical trocar site. It may occur at an extra-umbilical site if the trocar size is >5 mm. Kadar *et al.* (1993) reviewed six cases of incisional hernia amongst 3560 operative laparoscopies (incidence 1.7/1000) and made the observations shown in Table II.

**Recognition**

The patient presents with pain and a tender swelling over the hernia site, often within 2 weeks of the operation. Other presentations include vomiting, diarrhoea and colicky pain, and may mimic gastro-enteritis (Trehan, 1996). There may be features of partial bowel obstruction, e.g., hyperactive bowel sounds (Beck and McQuillan, 1994), because the herniation involves only a portion of the small bowel. The diagnosis may be established with the help of an X-ray of the abdomen (which may show bowel dilatation and fluid levels), ultrasonographic studies or computerized tomography. A loop of bowel may be seen herniating through the fascia. A common mistake is to consider an abdominal hernia as a wound haematoma.

**Management**

The hernia may be confirmed by laparoscopy, following which it may be reduced and the rectus sheath defect repaired.

**Prevention**

1. Careful closure of the fascia whenever a ≥10 mm trocar is used at an extraumbilical site. When inserting the suture it is important that the edge of the rectus sheath is carefully identified with a clamp (e.g., Littlewood clamp) to ensure that the sheath is included in the suture. After the placement of the suture, the rectus sheath should be checked digitally to ensure adequate closure. Several other methods of closing the port defect have been described: a ‘J’ needle, which is disposable (Phipps and Taranissi, 1994); a Veress needle (Tsaltas *et al.*., 1996); a reusable Reverdin needle (El Dosoky, 1996). In all cases, the closure site should be inspected carefully using the laparoscope to ensure that the bowel or omentum has not been trapped in the suture.

2. Keeping the trocar valve closed whilst it is being withdrawn. A possible mechanism whereby the small bowel is trapped in the abdominal wall is as follows: if the trocar (especially >5 mm) is removed hastily whilst the valve is open, it would create a suction effect at the intra-abdominal end of the trocar, bringing along with it part of the bowel or omentum to the abdominal wall as it is being withdrawn. It is therefore advisable that all trocars should be removed with the valve closed.

3. The trocars in the secondary ports should be removed first, whereas the primary trocar should be removed...
last. This permits visual inspection of the peritoneal surface of each secondary port for any unusual findings such as bleeding or entrapment of the bowel or omentum.

4. The use of small (5 mm) trocars whenever possible (Chapron et al., 1996).


6. Muscle relaxation is frequently integral to the anaesthetic techniques employed. It is essential that the recovery of muscle tone by antagonizing the effect of the muscle relaxants should not occur until after all trocars have been removed.

Gas embolism
Gas embolism is a very rare but potentially life-threatening complication. Carbon dioxide may be introduced into a large vein via the Veress needle and trapped in the right ventricle, causing right outflow obstruction from the right ventricle into the pulmonary artery. Indicative features include sudden circulatory collapse, cyanosis, raised jugular venous pressure, a characteristic ‘millwheel’ murmur, a high arterial pCO₂ and a drop in end tidal carbon dioxide concentration. If carbon dioxide insufflation is still ongoing via the Veress needle, it should be stopped immediately and the tubing disconnected. Escape of blood via the open end of the Veress needle confirms the diagnosis. However, the Veress needle must not be removed (see the section Vascular Injury).

Recognition
The earliest sign of carbon dioxide gas embolism is a drop in end tidal carbon dioxide concentration, which is a result of decreased blood flow to the lungs. As all modern anaesthetic machines continually record end tidal carbon dioxide concentration, a drop in measurement calls for an immediate halt to further gas being introduced into the peritoneal cavity, followed by investigation to exclude the diagnosis.

Management
Carbon dioxide insufflation must be stopped immediately, but the Veress needle must not be removed. Cardiopulmonary resuscitation is required. The patient is rolled on to her left side to facilitate expulsion of gas from the ventricle (Yacoub et al., 1982). A central line may also be inserted to aspirate gas from the right ventricle. Alternatively, intra-cardiac gas aspiration may also be tried (Beck and McQuillan, 1994).

Prevention
A Veress needle should be inserted with the tap open and without connection to the insufflation machine. If it had been inadvertently introduced into a large vein, blood would be seen escaping via the open end, as the venous pressure in the vena cava and common iliac vein exceeds that of the atmospheric pressure. As a steep Trendelenburg position decreases venous pressure in the iliac vessels and vena cava, a steep Trendelenburg position should be avoided when creating pneumoperitoneum. Instead, the patient should be in the dorsal position (Corson et al., 1996). After pneumoperitoneum has been successfully created, the patient may then be put into the steep Trendelenburg position.

Atmospheric air embolism is more dangerous than carbon dioxide embolism because the former is less soluble in blood. For this reason, prior to insufflation, the air in the insufflation tube connected to the carbon dioxide tank should be flushed out. The space in the tube in use in our hospital has been measured to be 25 ml.

Shoulder pain
Although a minor complication, this is exceedingly common and is due to the presence of a significant amount of residual carbon dioxide in the peritoneal cavity, trapped under the diaphragm and causing irritation of the diaphragm and referred pain to the shoulder.

Prevention
Ensure that all the gas is removed at the end of the operation whilst the patient is still in the head-down Trendelenburg position. The patient should be warned of the possible occurrence of shoulder pain to avoid unnecessary anxiety.

Pneumothorax
Pneumothorax may occur if there is a congenital defect in the diaphragm. It may rapidly evolve into a tension pneumothorax with cyanosis, engorgement of neck veins, increase in airway pressure and classical signs of pneumothorax. This will be exacerbated by the use of nitrous oxide, which will preferentially fill the closed gas filled cavity and expand the pneumothorax. The nitrous oxide supply must be switched off and the patient supplied with 100% oxygen.
Carbon dioxide must be released from the peritoneal cavity followed by placement of a thoracostomy tube by an experienced anaesthetist or surgeon.

**Subcutaneous and pre-peritoneal emphysema**

Subcutaneous emphysema is usually benign and resolves on its own. No specific treatment is needed other than massaging the swollen anterior abdominal wall towards the nearest trocar site to express the trapped gas.

Pre-peritoneal emphysema is a common complication which may result from inserting the Veress needle at too shallow an angle from the horizontal and frequently occurs with obese patients because of the thickened abdominal wall. Although a benign complication, pre-peritoneal insufflation may result in abandonment of the laparoscopic procedure, which can be frustrating both for the patient and the surgeon. To avoid pre-peritoneal emphysema during closed laparoscopy in obese patients the Veress needle and the primary trocar can be inserted at an angle of or near 90°, as suggested by Semm (1987) and Loffer and Pent (1977). Alternatively, an open laparoscopic approach can decrease the risk of retroperitoneal vessel injury in the obese patient, but may be technically difficult because of the increased abdominal wall thickness. It has been suggested that direct insertion of the primary trocar is associated with fewer minor complications, such as pre-peritoneal, omental and subcutaneous emphysema, while there is no increase in vascular and bowel injury (Nezhat et al., 1991; Byron et al., 1993). However, studies involving large numbers of patients are required to confirm these findings.

**Cardiac arrhythmia**

 Bradycardia may occasionally follow the creation of pneumoperitoneum. There is a reflex vagal response to peritoneal distension (Carmichael, 1971; Borten, 1986). This response may have become more noticeable with the introduction of muscle relaxants lacking any inhibitory vagal action. This is often successfully managed by stopping the in-flow of gas to the peritoneal cavity and administering an anticholinergic agent. When the cardiac arrhythmia has settled, gas may be reintroduced slowly. Occasionally the arrhythmia may persist or cause significant concern, in which case the laparoscopy should be abandoned.

**Nerve injury**

Transient nerve injuries may occur during any procedure with incorrect positioning of the anaesthetized patient. The improper use of leg stirrups with the patient in the lithotomy position may expose the common peroneal nerve and also the saphenous nerve. Schwartz (1993) reported two transient nerve injuries amongst 45 consecutive patients undergoing laparoscopic hysterectomy. One involved the femoral nerve and the other the peroneal nerve. Correct positioning of the patient, especially when undergoing prolonged laparoscopic surgery, is necessary to avoid nerve compression injury.

The stirrups should be well padded to avoid nerve compression. With the use of the Valtchev uterine mobilizer (Grunstein et al., 1982) one can avoid placing the patient’s legs in stirrups, as the uterus can be adequately mobilized with the legs in the horizontal position. Padded shoulder braces are also useful to prevent nerve injury to the neck or shoulder when the patient is placed in the steep Trendelenburg position.

**Venous thrombosis**

Although venous thrombosis is relatively uncommon following laparoscopic surgery because of earlier mobilization, venous thrombosis and pulmonary embolism do occur following laparoscopic pelvic surgery. In an analysis of 3189 cases of laparoscopic hysterectomy, Garry and Phillips (1995) were able to identify six cases of pulmonary embolism. Apart from the use of stockings and subcutaneous heparin for prophylaxis in those having major laparoscopic surgery, the filling pressure of carbon dioxide should be set at ≤13 mm. If the filling pressure rose significantly >15 mm mercury, it would impede venous return from the vena cava and consequently would cause venostasis predisposing to deep vein thrombosis.

**Avoiding complications arising from the use of electrical energy**

The principles of electrosurgery have been reviewed by Vancaille (1994). Complications of electrosurgery at laparoscopy may result from three situations, namely accidental burn, direct coupling and capacitative coupling. Some guidelines to avoid unintended burns during laparoscopic surgery are described below.

**General precautions**

1. Ensure sufficient intra-abdominal free space as this reduces the likelihood of inadvertently touching a vital organ such as the bowel. This may be achieved by adequate pneumoperitoneum and by decreasing the volume of hollow organs such as the stomach (nasogastric tube suction), bowel (pre-operative bowel preparation) and bladder (indwelling Foley catheter). If
for any reason adequate pneumoperitoneum cannot be sustained because of leaking via the ports, or following the introduction of gas into the subrectus space, it would be unwise to proceed with laparoscopic surgery.

2. Optimize access to the site of surgery, e.g. by dividing adhesions prior to definitive surgery so that important organs such as the bowel may be pushed away from the site of the surgery.

3. Use bipolar instruments whenever possible.

4. Activate the electric energy only when the tip of the instrument is in contact with the target tissue and in the view of the laparoscope. Use the lowest possible power setting.

5. The tip of the diathermy instrument may remain hot for several seconds after use. After its use, keep it in view until it has cooled or whilst it is removed from the body. The cooling of the tip may be facilitated by dipping it in a pool of fluid in the pouch of Douglas or irrigating with fluid.

6. Avoid diathermy close to the bowel.

7. If there are dense bowel adhesions, especially in the presence of advanced endometriosis, consider open surgery instead, unless the surgeon is very experienced in advanced laparoscopic surgery.

8. The laparoscopic surgeon should be aware of warning signs of metal-to-metal arcing during surgery, such as involuntary contraction of abdominal muscles, hissing sounds within the trocar or ‘lightening’ artefacts on monitors and electronic equipment.

9. A reduction in the expected electrosurgical effect at a given power setting and energy mode may indicate that some of the electroenergy has dissipated away from the tip of the active electrode. Do not keep increasing the power output. Instead, check the application of the neutral plate, and the insulation of the active electrode.

**Avoidance of capacitative coupling**

1. To avoid capacitative coupling, do not use plastic abdominal wall grips (anchors) in conjunction with metal cannulae. Non-insulated instruments, e.g. laparoscope and irrigators, should be passed only through all metal cannulae/anchor combinations. Insulated instruments may be used in conjunction with all plastic, or all metal cannulae/anchor combinations.

2. Active shielding of instruments. This may be achieved by a special computerized device that continuously monitors electrical energy within and around the active instrument (Electroshield®, Valley Lab, London, UK). Capacitatively coupled energy will be leaked back to the generator, whereas directly coupled energy, once detected (indicating insulation failure), will automatically turn off the power supply.

3. When coagulating tissue to achieve haemostasis, deliver short sharp pulses of electrical power and avoid prolonged activation of the electrode.

**Avoidance of direct coupling**

Activate energy only when the whole active part of the instrument is visualized.

**Avoidance of insulation failure**

1. Remember that if the ‘non-active’ or insulating part, usually the shaft of the instrument, is defective, this may lead to electricity leak. Avoid contact of any part of the instrument (including the shaft) with the bowel or other important organs, when electricity is in use.

2. Never reuse single-use electrodes. The insulation may not be suitable for repeated use or repeated sterilization.

3. There is no need to use disposable electrical instruments, which are expensive; it is perfectly acceptable to use good quality reusable instruments, according to their recommended life span. Prior to using any laparoscopic electrical instrument, inspect the insulating part for obvious damage.

4. Discard ports that have sharp edges which may damage electrode insulation. If the instrument does not slide in and out of the port smoothly, there is a significant risk that the protecting sheath may be damaged. A cannula with a trapdoor valve is safer than a cannula with trumpet valves because the latter may damage the insulation of electrosurgical probes.

5. Electroshield (see above).

**Conclusion**

Laparoscopic surgery has many advantages, but it is not without complications. Many of the complications described above are different from those of open laparotomy. Each laparoscopic surgeon should be aware of the potential complications and how they can be prevented. The laparoscopic surgeon should also learn how to recognize complications early, and manage them safely and efficiently.

**References**


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